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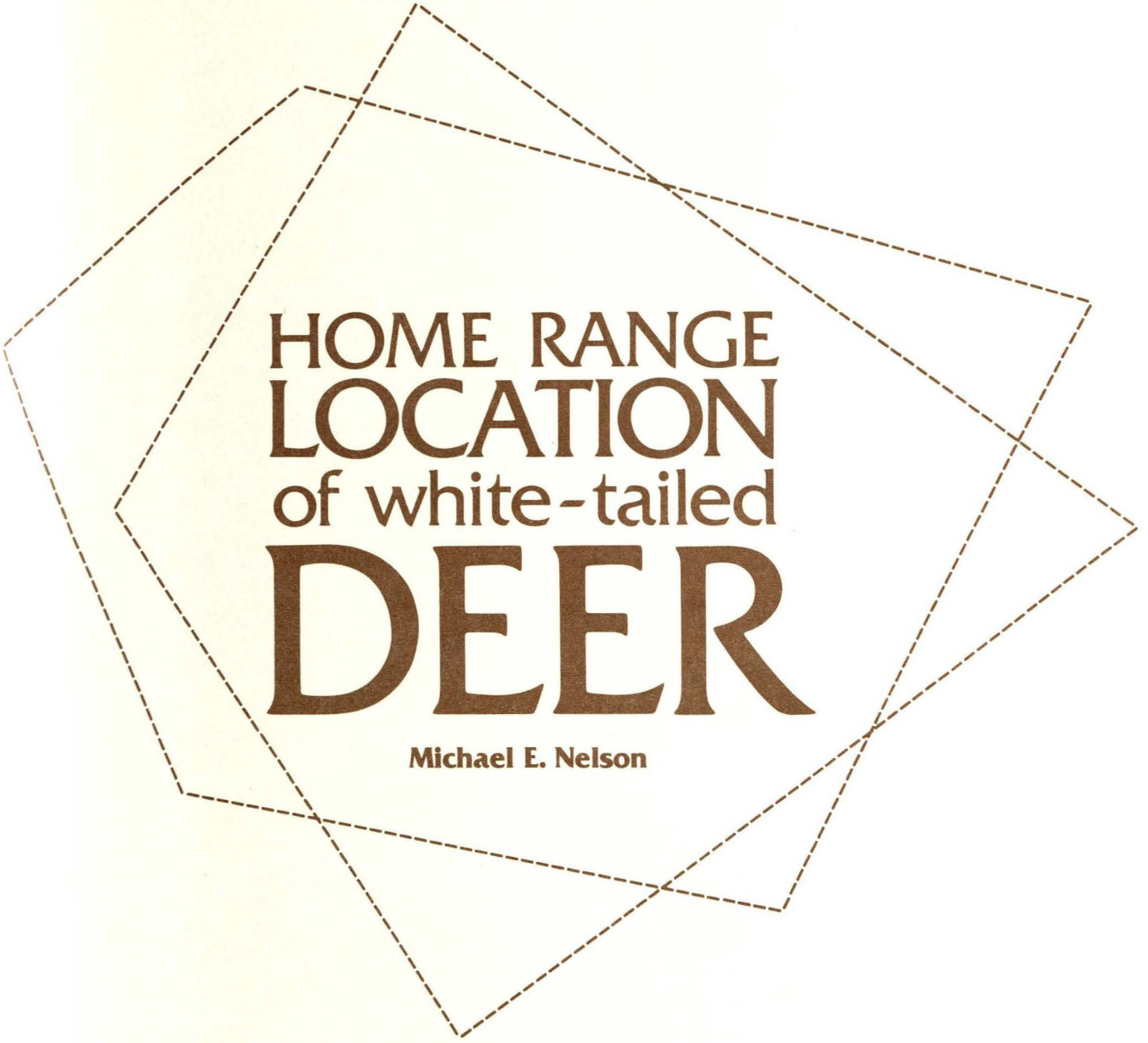

HOME RANGE LOCATION of white-tailed DEER

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It is generally accepted that disturbances such as fire and logging improve deer (*Odocoileus virginianus*) habitat and increase deer numbers in heavily forested regions. Many studies have reported increased browse production and utilization, higher deer numbers, and higher hunter harvests following natural and human-caused disturbances to forest habitat (Westell 1954, Taylor 1956, Halls and Crawford 1960, Behrend and Patric 1969, Krefting and Hansen 1969). However, these increases could result from greater productivity by resident deer in response to better range, migration to the improved range, or simply from a redistribution of feeding activity by resident deer.

Most early habitat studies were conducted without the knowledge of local deer movements and most assumed real increases in deer numbers were occurring, or that deer migrated to the better range. However, recent work in northeastern Minnesota has indicated that migrations and home ranges were traditional and appeared to be determined more by early social experience and learning than by habitat (Nelson and Mech [In press.]). It is now apparent that deer movements are a complex part of deer ecology and should be examined when proposing or evaluating habitat management.

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The purpose of the present paper is to report on home range location and how it is influenced by movement traditions, social bonds, and available habitat.

STUDY AREA

The study area was located in the Superior National Forest (SNF) of northeastern Minnesota and encompassed roughly 5,300 km^2 (fig. 1). Half of the area was accessible by logging roads, and half was located in the roadless part of the Boundary Waters Canoe Area (BWCA).

The common soils of the area are clay loam, sandy loam, and peat (Grigal and Arneman 1970). The climate is cool-temperate (Hovde 1941) with snowfall averaging over 150 cm during 5 months of winter beginning in mid-November.

Plant communities of the area were described by Buell and Niering (1957) and Ohmann and Ream (1971). The upland forests are mixed coniferous-deciduous, with balsam fir (*Abies balsamea*), white spruce (*Picea glauca*), jack pine (*Pinus banksiana*), black spruce (*Picea mariana*), aspen (*Populus tremuloides*), and white birch (*Betula papyrifera*) predominating. Wet lowlands are forested by black spruce, tamarack (*Larix laricina*), white cedar (*Thuja occidentalis*), and black ash (*Fraxinus nigra*).

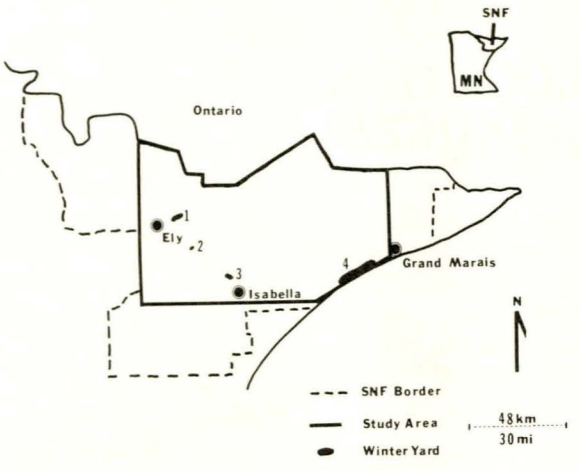

Figure 1.—*Study area.*

The northern part of the study area is inside the BWCA, of which 40 percent has never been directly altered by man and is forested with mature timber (Heinselman 1973). Areas logged in the late 1800's and early 1900's now support mature forests also. In contrast, much of the southern portion has been logged within the past three decades. Peek *et al.* (1976) provided the management history of these forests. The deer in this study lived in both regions and overwintered in the Garden Lake, Kawishiwi Campground, and Bushel Lake deeryards (Nelson and Mech [In press.]).

Deer home ranges were forested with various combinations of the following major forest types: 120-year-old jack pine, 40-year-old jack pine plantation, 100-year-old lowland black spruce, 30- and 90-year-old aspen, 12- to 20-year-old jack pine-aspen (the jack pine was planted), and 0- to 1-year-old aspen in a clearcut.

The major causes of deer mortality in the study area are human hunting and predation by wolves (*Canis lupus*) (Nelson and Mech [In press.]).

METHODS

Deer were captured on their winter ranges by means of a rocket net, traps, and drug-loaded darts. Most deer were immobilized via phencyclidine hydrochloride (Sernylan, Bio-ceutics Laboratories, Inc.)[2] combined with promazine hydrochloride (Sparine, Wyeth Laboratories, Inc.) (Seal *et al.* 1970). Some fawns were handled without drugs.

Once immobilized, all deer were sexed, eartagged, weighed, classified as a fawn or adult, blood-sampled, and radio-collared (Cochran and Lord 1963). Analysis of 24 parameters of hematology, blood chemistry, and endocrinology were made and interpreted (Seal *et al.* 1978). The radio collars and receiving equipment were built by the University of Minnesota Bioelectronics Laboratory and the AVM Instrument Co., Champaign, Illinois.

Deer were radio-tracked from the ground (Marshall and Kupa 1963) and from aircraft (Mech 1974). Location error for ground tracking averaged 0.4 ha (0-2.2 ha) and was minimized by obtaining radio fixes within 0.4 km of the deer and by taking bearings at approximately right angles (Heezen and Tester 1967). The location error for aerial tracking was measured at 0.02 to 1.87 ha (Hoskinson 1976).

Relocation rates varied from one to five fixes per day, with the higher rates providing the habitat selection data. Tracking was distributed during three periods of the day: 0600-1000 hours (early), 1000-1800 hours (midday), and 1800-2200 hours (late). Little tracking was done from 2200 to 0600 hours and was eventually lumped with the early-late data. Deer were tracked May through August, but most intensively in July and August. All deer were radio-tracked at least once a week throughout the year as a part of another study (Nelson and Mech [In press.]).

All tracking data were plotted on aerial photographs (scale 1:15840), and each deer's home range was determined by the minimum area method (Mohr 1947). The habitat (dominant tree species) the deer was in was recorded for each deer relocation. Habitat type boundaries and classifications were verified from USDA Forest Service records, aerial photographs, and aerial inspection. Some error polygons (Heezen and Tester 1967) from the ground tracking included more than one habitat type, so they were subsequently excluded from the data.

[2]*Mention of trade names does not constitute endorsement of the products by the USDA Forest Service.*

The habitat selection data were analyzed separately for each deer since there were differences in types and proportions of the various habitats available to each deer. Chi-square tests of independence were used to determine differences in habitat use between months and between time-of-day tracking periods. Differences were considered significant at $P<0.05$ and highly significant at $P<0.005$. Data with significant differences were subsequently treated separately while nonsignificant data were lumped. Monthly and period-of-day data were next tested by goodness-of-fit comparisons to determine if major habitat types were used in proportion to their availability.

The hypothesis was that a deer used habitat types in proportion to their occurrence within the deer's home range. A significant result implied that the deer did not select habitats in proportion to availability. Next, 90 percent confidence intervals were determined for the proportion of observed use for each habitat type in order to determine significant differences for expected and observed utilization (Neu *et al.* 1974). Habitats that were used more than expected were considered "preferred" while those that were used less than expected were considered "avoided". Confidence intervals were not constructed for data failing to meet the sample size criteria of Neu *et al.* (1974). Determination of habitat preferences from those data was therefore more subjective.

An examination of food habits and feeding strategy was beyond the scope of this study. Discussion of feeding is, therefore, based only on cursory observations.

RESULTS

Forty-six deer were captured and radio-collared from 1974 to 1977 for studies of deer migration, home range, and social organization (Nelson and Mech [In press.]). Seven of these (one adult buck, two adult does, and four 12-month-old buck fawns) were subsampled to examine summer habitat selection. Two of the fawns (Nos. 320 and 372) were the offspring of one of the does (No. 318).

Two 12-month-old buck fawns, No. 342 in 1974 and No. 68 in 1975, provided the most detailed data on habitat usage and offered the opportunity to examine selection differences between deer inhabiting the same area. These fawns were nonmigratory and summered in the same area; each was shot by hunters the fall after it was studied. Both were radio-tracked three to five times a day; the dawn, dusk, and night hours provided three-fourths of the data, daylight the rest (table 1). Buck fawn 342 was located almost exclusively from the ground, but buck 68 was tracked from aircraft 45 percent of the time. Both deer had similar size home ranges (table 1).

The remaining five deer (one adult buck, two adult does, and two sibling buck fawns) migrated to their summer ranges and were located from aircraft almost daily in May and twice a day during three 10-day tracking periods in June, July, and August 1975 (table 1). Doe 318 and her fawns (Nos. 320 and 372) occupied the same summer range even though the fawns split apart from their mother (Nelson and Mech [In press.]). The other doe (No. 66) established a home range which overlapped with doe 318's range, but their centers of activity (Hayne 1949) were different (Nelson and Mech [In press.]). The adult buck (No. 64) summered in a different area entirely, but the habitat of his home range was similar to the habitat available to these other deer.

Table 1.— *Location and home range data*

Deer	Sex	Age	Month tracked	Locations[1] E	M	L	Total	Home range
		Years		*Number*				*Hectares*
68	M	1	June	8	11	12	31	
			July-August	36	20	45	101	177
342	M	1	July 13-Sept.18	36	34	45	115	120
318	F	Adult[2]	May-Aug.	18	30	26	74	199
320	M	1	May-Aug.	19	29	26	74	197
372	M	1	May-Aug.	14	32	29	75	220
64	M	Adult[2]	May-Aug.	13	24	22	59	549
66	F	4	May-Aug.	19	34	27	80	100

[1]Period of the day: E=early; M=middle; L=late.
[2]Age unknown.

Habitat Selection

Bucks 68 and 342 inhabited the exact same area and utilized the same forest stands. The habitat within their home range included stands of 30- and 90-year-old aspen and 100-year-old lowland black spruce, two aspen clearcuts, and a 40-year-old jack pine plantation. The two deer each had similar proportions of these types available (table 2.)

Habitat selection by buck 68 varied significantly between months; the June data differed from the July-August data ($P<0.005$). The June data did not allow a test for time-of-day differences in selection. The subsequent "goodness of fit" comparison for June showed that buck 68 used the mature aspen habitat more and the other types less than expected based upon their proportions within his home range ($P<0.01$, table 2). Lowland black spruce was not used, although it constituted 5 percent of his range.

No. 68's July-August data showed large differences in habitat selection between midday and early-late hours ($P = 0.01$). During early and late hours the buck preferred aspen clearcuts (second season of growth) and avoided mature aspen and black spruce types ($P<0.005$, table 2). The mature

Table 2.— *Habitat selection analysis for bucks 68 and 342*

Deer and period	Habitat	Proportion of each habitat	Locations: Number expected in each habitat[1]	Locations: Number actually observed	Locations: Proportion with 90% confidence interval[2]	Selection[3]
68 June	Aspen	0.66	20	29	[4]0.94	+
Morning through evening	Clearcut	.20	6	1	[4].03	—
	Plantation	.09	3	1	[4].03	—
	Spruce	.05	2	0	[4].00	—
	Total	1.00	31	31	1.00	
July 1 to Aug. 31	Aspen	.66	53	43	.53 ± .12	—
Morning and evening	Clearcut	.20	16	33	.40 ± .12	+
	Plantation	.09	7	5	.06 ± .06	0
	Spruce	.05	5	0	.00 ± .00	—
	Total	1.00	81	81	1.00	
Mid-day	Aspen	.66	13	18	NS	
	Clearcut	.20	4	2	NS	
	Plantation	.09	2	0	NS	
	Spruce	.05	1	0	NS	
	Total	1.00	20	20	NS	
342 July 13 to Sept. 18	Aspen	.65	53	46	.57 ± .12	0
Morning and evening	Clearcut	.13	10	29	.36 ± .11	+
	Plantation	.13	11	4	.05 ± .05	—
	Spruce	.09	7	2	[4].02	—
	Total	1.00	81	81	1.00	
Mid-day	Aspen	.65	22	29	[4].85	+
	Clearcut	.13	4	1	[4].03	—
	Plantation	.13	5	4	[4].12	0 or —
	Spruce	.09	3	0	[4].00	—
	Total	1.00	34	34	1.00	

[1]If deer randomly located

[2]Proportion observed = $\frac{\text{number observed in each habitat}}{\text{total number observed}}$

[3]If proportion observed is higher than proportion expected selection (+); if lower, selection (—); if same, selection (0).

[4]Sample is inadequate to determine confidence interval.

jack pine plantation was used in proportion to its availability. During midday he seemed to avoid aspen clearcuts prefering mature aspen, but the comparisons were not statistically significant. The pine plantation and black spruce stands received no recorded use.

Deer 342 was tracked from July 13 through September 18 and showed no significant monthly differences in habitat usage. This is consistent with deer 68's July-August data. However, habitat selection by deer 342 did vary according to time of day. Habitat use in the early and late hours was almost identical, and it differed sharply from the midday data ($P<0.005$). As with buck 68, buck 342 used the aspen clearcuts (first season of growth) early and late in the day more than would be expected based on the proportion of clearcuts within his home range ($P<0.005$, table 2). In doing so, he avoided the mature jack pine plantation and black spruce lowlands. Mature aspen stands were used in proportion to their occurrence. Disproportionate selection of habitat was not highly significant for the midday period ($P<0.05$). He avoided the clearcuts during midday and used the mature aspen stands more than expected (table 2). He was neutral to or avoided the pine plantation at midday and avoided the black spruce type at all times (table 2).

The other five deer lived in areas with habitat types different from those available to deer 68 and 342. Available were 120-year-old jack pine, 30-and 90-year-old aspen, 12- to 20-year-old jack pine-aspen (planted jack pine), 100-year-old black spruce, and wet lowland grass. Data from these deer were more scanty (two observations per day) and included only daylight tracking periods. Four of the deer (Nos. 64, 318, 320, and 372) showed no differences in habitat selection between months or among three periods of daylight.

Nonetheless, there were highly significant differences between expected and observed use of habitat ($P<0.005$), and all four deer made similar choices (table 3). There was a marked preference for the jack pine-aspen type, a common avoidance of the black spruce type, and neutrality to or avoidance of the lowland grass type. Three of the four deer used mature aspen in proportion to its occurrence. Two of the three deer that had mature jack pine available used it in proportion to its availability, and the third avoided it.

The fifth deer, doe 66, had different habitat available and selected different habitat from other deer. Her habitat usage in May-June was different from that in July-August ($P<0.025$). She used mature aspen more than expected in early summer (table 3), and was neutral to jack pine-aspen and lowland types at that time. By late summer she was using the jack pine-aspen less than expected considering its availability, and the wet lowland grass type more than expected. The mature aspen and black spruce types were used according to availability. Time-of-day differences in the data were not statistically significant, but they did suggest a selection for wet lowland grass late in the day. The late observations showed a highly significant preference for lowland grass, ($P<0.005$), while early and midday data showed no such trend.

Three of the four deer that showed similar preferences in habitat were members of the same family group (doe 318 and fawns 320 and 372). As indicated earlier, the 12-month-old fawns were separated from their mother during summer. However, the siblings were together 80, 40, and 100 percent of the time in June, July, and August, respectively (Nelson and Mech [In press.]).

Activity

Both telemetry and direct observation provided information on the activity patterns of deer 68 and 342 as they selected habitats in July and August.

Table 3.— *Habitat selection*[1] *by deer 64, 66, 318, 320 and 372*[2]

Deer	Mature Jack pine	Young Jack pine-Aspen	Mature Aspen	Black spruce lowland	Lowland grass
318	–	+	0	–	–
320	0	+	0	–	–
372	0	+	0	–	–
64	NA[3]	+	–	–	0
66:					
(May-June)	NA[3]	0	+	0 or –	0 or –
(July-Aug.)	NA[3]	–	0	0 or –	+
(Late only)	NA[3]	0	0	0 or –	+

[1]Selection: + = "for"; – = "against"; 0 = "neutral".

[2]Deer 320 and 372 were the yearlings of deer 318 and lived within her home range during the tracking period. Deer 66's home range overlapped 318's range. Deer 64 lived in a different area.

[3]Not available.

The thick cover in the aspen stands preferred by both deer during midday did not permit much observation. However, the facts that both deer were often flushed from beds in those stands and that there was also considerable sign of feeding there, indicates the stand was used for both feeding and bedding. By late afternoon, both deer moved into the clearcuts where they were observed feeding on the large leaves of aspen suckers. The radioed deer, and other deer, fed and bedded in the cutting during the night but moved back to the timber at dawn.

Data from a different deer (doe 128) indicated that activity is least during the day and greatest after sunset. Doe 128 was radio-tagged with an activity transmitter in late July 1977 and was monitored for 41 hours on 9 days in late July and early August. She was active throughout the day, especially between 1600 and 0200 hours (fig. 2). She was not active at dawn, as bucks 68 and 342 typically were, but the data are scanty and should be examined only for a general view of activity. Other workers have observed long periods of inactivity during the day in summer with increased activity early and late in the day (Kammermeyer and Marchinton 1977). The activity is usually a result of movement into open feeding areas at sunset and a return to cover at dawn (Montgomery 1963, Thomas 1966, Marchinton and Jeter 1966, Tibbs 1967).

Migration Tradition and Habitat Availability

Four of the five migratory deer examined for habitat preferences in this study migrated 8 km between the same winter and summer ranges for the 3 years they were studied (Nelson and Mech [In press.]). The fifth deer (buck 64) made one 14-km spring migration but was killed by wolves during his return migration the next winter. The fawns of doe 318 migrated with their mother during their first fall and spring and were even found with her on their summer range 2 weeks before their second birthday.

All four deer wintered adjacent to the preferred clearcut habitat used by bucks 68 and 342, and all migrated through aspen clearcuts on the way to more mature habitat in their summer ranges. In fact, yearling bucks 320 and 372 made a few midsummer forays to those clearcuts, but such visits were of 1 or 2 days duration. At 2 years of age, buck 320 dispersed to an area adjacent to his winter range and used young aspen clearcut within that area. However, he continued to make a spring migration to his birth home range until he was killed there by wolves when 4 years old. Buck 372 continued to summer in the area of his birth and was shot when he was 2.5 years old. Another buck fawn in the only other family group studied also adopted the migration tradition and home range of his mother. He was either migrating or making a rutting movement when shot at 2.5 years of age.

Other radioed deer made similar traditional migrations through habitats preferred by some deer to habitats avoided by others. For example, three other adult does made the same migration as does 318 and 66, one of which was an associate of No. 66. One of the others migrated with her fawns to the mature pine habitat available to, but avoided by, No. 318. Two other does from a different deeryard migrated through young clearcuts and summered in very old conifer habitats. Finally, one orphaned female fawn (No. 116) wandered extensively for 2 weeks during her first spring (Nelson and Mech [(In press]). Her movements took her through several clearcuts, a 4-year-old burn, and other young forest areas, but she returned to her winter range which was dominated by mature aspen. (Her radio expired in early summer.) Similar behavior was observed in Arkansas where two radioed deer inhabited a pine forest when other deer only a few kilometers away avoided the pine type in favor of a burned area (Pledger 1975).

DISCUSSION

Intensive tracking data on two fawns using the same area during different summers indicated that the two deer used their habitats similarly. This suggests that certain habitats are preferred over others and that different deer will display the same pattern of selection when presented with the same choice of habitat. One of the two also demonstrated that habitat selection during summer can change in response to browse availability. The tracking period on the second deer was too short to detect any seasonal change.

The June data from one of the fawns indicated that the mature aspen type was preferred while a clearcut was avoided. Radioed deer elsewhere in

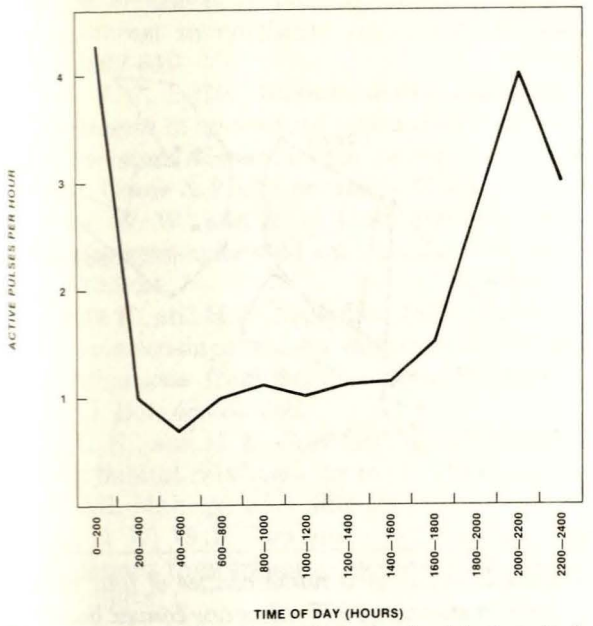

Figure 2.—*Activity of Doe 128, tracked in late July and early August 1977.*

northern Minnesota also avoided a clearcut in late spring and early summer (Pierce 1975). Both cases suggest that clearcuts may be of limited value during that period.

Other workers have suggested that there is a selection for grassy openings in spring and early summer (McCaffery and Creed 1969, Kohn and Mooty 1971, Pierce 1975). Roadsides and small openings were available to the one deer I intensively tracked in early summer, and I did see him feeding along a grassy road in May, however, the tracking rate was too low and the error too large to quantify such selection during that month. Other radioed deer were occasionally seen feeding in open areas, suggesting that selection for open sites was possibly occurring.

In contrast to early summer, the July and August data from the two yearlings indicated that the aspen clearcuts were highly preferred over the mature timber as feeding areas early and late in the day. The shift may have been due to extensive browsing of aspen leaves which were not available until late June and which were only available in quantity in that habitat. A change in availability of associated species may have also been partly responsible. Kohn and Mooty (1971) observed intensive use of clearcuts in northern Minnesota in July and August. Pledger (1975) documented a similar selection for a burned area and avoidance of pine forest in Arkansas. Shifts in movement as a result of changing food supply have also been reported by Byford (1970) and Pledger (1975).

Movements from the clearcuts at dawn were probably the result of a need for cover (security from predation) and possibly shade. Other radioed deer in subsequent years have bedded during the day in 4- and 6- year-old aspen clearcuts composed of dense stands of 3 m tall aspen. Apparently such stands provide adequate daytime cover.

The less intensive data from the other radioed deer also showed a habitat selection response. Four of five deer showed a preference for young jack pine-aspen while avoiding or using proportionately mature jack pine, aspen, and lowland black spruce habitats. The fifth deer (doe 66) showed a late summer and late-in-the-day selection for a grassy stream where it fed on aquatic vegetation (Hennings 1977). In contrast to the other four deer, she avoided the young jack pine-aspen type when selecting for the stream area. Her example suggests that individual differences in habitat usage do exist since her home range actually overlapped with three of the other four deer. Those other three deer were seen using aquatic sites but only in early summer and not with the same intensity as doe 66.

The radioed deer in this study generally avoided or used mature upland and lowland conifer habitats proportionate to their availability during summer. This indicated that when a choice is available deer select young deciduous or deciduous-coniferous upland habitat. This is not to say that deer do not live in mature conifer habitat. On the contrary, some radioed deer studied by Nelson and Mech [In press.] summered in mature pine forests exclusively. One 2-year-old buck even used a large black spruce bog in combination with some upland conifer sites.

The data indicate that summer habitat management in northeastern Minnesota would benefit deer most if it focused on upland deciduous or deciduous-coniferous habitats. However, managers should be aware that most deer probably live where they do because of factors other than habitat preference.

The record of two does (Nos. 318 and 326) whose fawns migrated with them to their traditional ranges and continued to do so after family breakup, lends further evidence that any selection of habitat is secondary to the influence of tradition and learning. In the one case studied in detail (No. 318), the siblings selected the same habitat as their mother even after separating from her and exploring away from the immediate area. The habitats available to them at 12 to 15 months of age were, therefore, determined by previous learning. One of these yearlings was the deer that dispersed to its winter range but continued its spring migration until its death at 4 years of age.

Selection of the best habitat may be most important and reach its greatest expression in the case of dispersing yearlings. However, the few cases of dispersal I have studied indicate that new home ranges are established in areas that the dispersers have visited during migrations. The wandering and eventual return of the orphaned female fawn in this study cannot be considered dispersal, but her example does suggest the importance of learning and tradition. Dispersers are no doubt influenced by the same phenomena.

It is quite possible that differences in habitat availability and selection are related to other social factors as well. The home ranges of does 66 and 318 overlapped each other in summer 1975, but the overlap stopped during the post-fawning period and started again later in fall, suggesting that there may be some form of avoidance by does during the post-fawning period (Nelson and Mech [In press.]). Also, by summer 1977 there were two other radioed does using the general area inhabited by does 66 and 318. Their home ranges overlapped but were distributed such that each deer had its own area of use with a different activity center (fig. 3). One other study in north-central Minnesota also found a similar pattern of home range distribution of does (Waddell 1973). The effect of such a system of range use would tend to vary the proportion of habitats available to individual deer inhabiting any one area and could account for differences in habitat selection between deer.

The migrations and strong traditions of the deer in this study, and of others reported by Nelson and Mech [In press.], suggest that home range location and therefore, habitat availability, is determined more by early social experience, learning, and tradition than by some innate ability to select the best habitat.

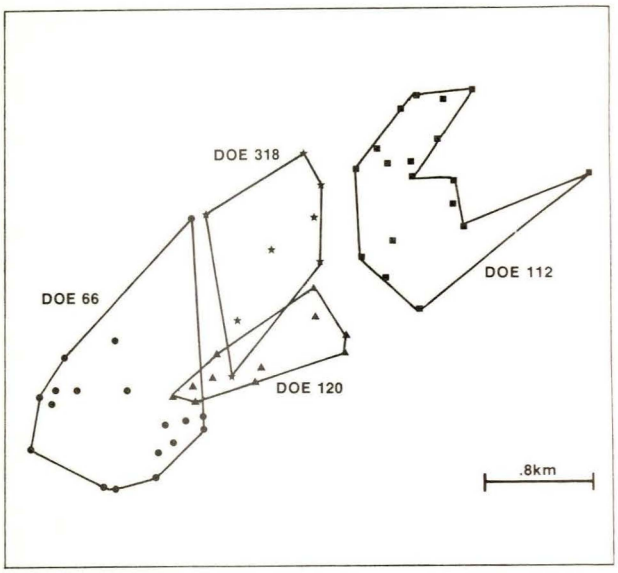

Figure 3.—*Adjacent home ranges of four radioed does in summer 1977. (The one convex boundary is the result of a lake bordering Doe 112's range.) Each doe had at least one fawn during the tracking period. Doe 66: May 9-August 24; Doe 112: May 17-September 1; Doe 120: May 9-July 2 (radio expiration); Doe 318:May 17 - June 13 (radio expiration).*

The implications for habitat management in northeastern Minnesota are: summer ranges are widely scattered so habitat management for summer range must be extensive to have any influence on the population; in winter management can be concentrated in a few major yards where most deer will be found. The goals or objectives of habitat management in this area should be designed and evaluated with respect to the migratory traditions and social behavior in the deer population. Failure to consider this aspect of deer ecology may lead wildlife managers to erroneous conclusions about the effectiveness of habitat management.

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